Field Test Program for Long-Term Operation of a COHPAC® System for Removing Mercury

DOE/NETL's
Mercury Control Technology R&D
Program Review
Pittsburgh, PA July 12-13, 2005

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Team Members

Primary funders:

- **DOE / NETL**
- **EPRI**

Co-Funders:

- **Southern Company**
- **Alabama Power**
- **Ontario Power Generation**
- **TVA**
- **Duke Power**
- **First Energy**
- **Hamon Research-Cottrell**
- **Arch Coal**
- **Norit Americas**
- **ADA-ES**

Testing:

- **ADA-ES**
- **Southern Research Institute**
- **Reaction Engineering**
- **Grubb Filtration Testing Services**
- **Hamon Research-Cottrell**
- **Weston**

Alabama Power E. C. Gaston Unit 3

- 270 MW firing a variety of low-sulfur, washed eastern bituminous coals
- Particulate Collection:
  - Hot-side ESP; SCA = 274 ft^2/kacfm
  - COHPAC™ baghouse A/C ratio ~ 8 ft/min
- Tested ½ of Unit 3
  - B-side COHPAC
  - ~ 500,000 acfm

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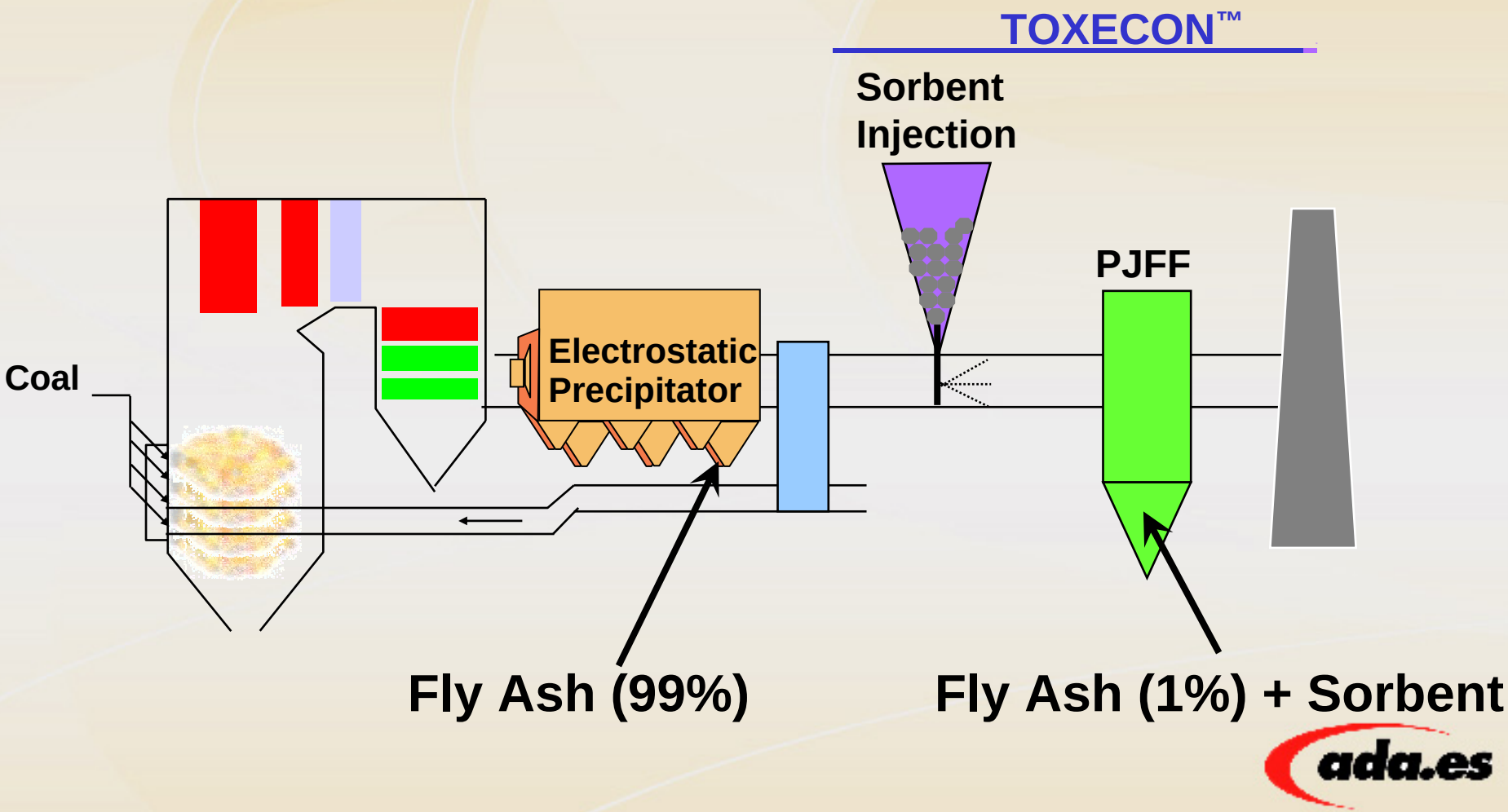
TOXECON™ Configuration



Phase I and II Test History

Phase I Results

- Up to 90% mercury removal was achieved for short-term tests
- COHPAC® cleaning increased proportionally with carbon injection
- Two-week test injection rate limited by cleaning frequency (1.5 p/b/h max)
  - Average ~ 78%
  - Maximum ~ 94%
  - Minimum ~ 36%

Phase II Goals

- Determine maximum mercury removal
  - existing conditions
  - long-term, continuous operation
- Evaluate options to overcome cleaning limitations and achieve higher mercury removal
  - High perm bags
  - Lower air-to-cloth ratio

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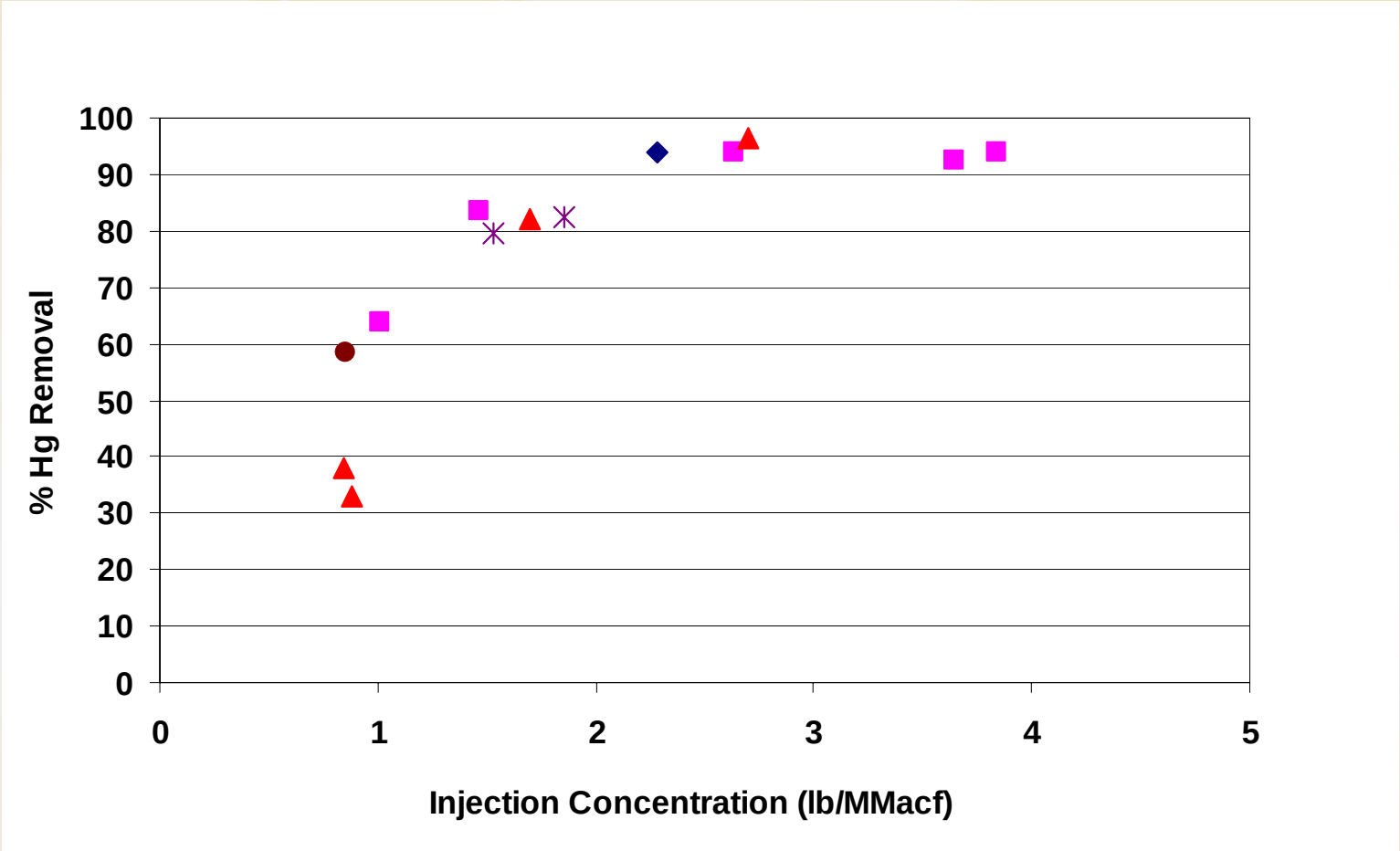
Phase I Test Results With Activated Carbon (2001)



Gaston Long-Term Test Plan

1. Six month test with original 2.7-denier bags
   - Bags installed 3 years before test started
2. Six month test with 7-denier bags
   - High-perm bags
3. Alternative carbon tests

2.7 Denier Long-Term Test Overview

- Injected Activated carbon over 17 weeks
- Limited ACI rate due to poor performing ESP

Inlet Loading (gr/scf)	Inlet Loading (gr/acf)	Injection Concentration (lbs/MMacf)	Injection Rate (lbs/h)
<0.1	**~0.07**	**0.52 or 0.66**	**16 or 20**
<0.2	**~ 0.14**	**0.35**	**10**
>0.2	**~ 0.14**	**0**	**0**

- Excessive bag cleaning rates during test program
  - Baseline: ~2 p/b/h (1.5 p/b/h upper limit)
    - Hg removal varied between 0 and 90%
  - Injection: 3.6 avg. p/b/h over 17 weeks of testing
  - Excessive p/b/h reduces bag life

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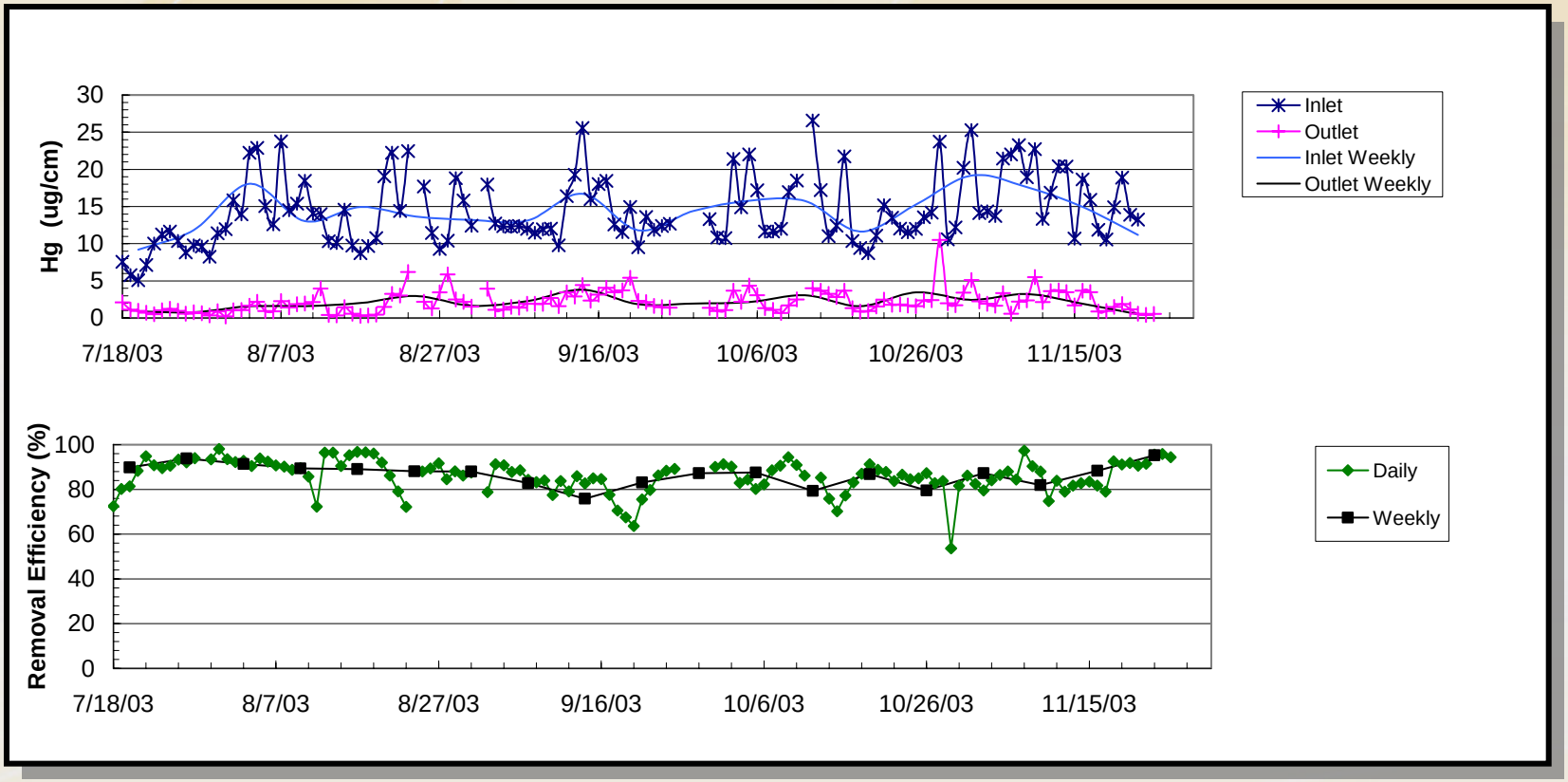
2.7 Denier Daily & Weekly Average Mercury



Note: Standard deviation of weekly removals ranged from 3 – 15%

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Low Load/Low Flow Test

- Current air-to-cloth ratio of 8.0 ft/min is too high for TOXECON™
- Low load test conducted to simulate operation at air-to-cloth ratio of 6.0 ft/min
  - 72 hours of operation at low, steady load (195MW)

Unit 3 Boiler Load	270 MW	195 MW
Flow (acfm)	520,000	375,000
A/C Ratio	~8.0	~6.0

Results from Low Flow Test

Injection Rate (lb/h)	Injection Concentration (lbs/MMacf)	Inlet Hg Concentration (µg/Nm3)	Outlet Hg Concentration (µg/Nm3)	RE (%)	Cleaning Frequency (pulses/bag/hour)
20	0.9	20.6	3.2	84.2	0.6
45	2.0	22.2	1.0	94.6	0.8
70	3.3	21.4	0.61	97.1	1.4

- Steady levels of Inlet mercury during this test period
- Inlet grain loading to baghouse decreased
- Pulse frequency was below upper limit of 1.5 p/b/h
- High levels of mercury removals were demonstrated over a relatively short test period (1 day, 1 day, 8 hrs)

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7.0 Denier Bag Tests

- High-Perm Bags
  - EPRI Development
  - 30 vs. 130 cfm/ft^2 @0.5”H_2O
- Demonstrate improved cleaning performance
- Increase carbon injection to achieve higher average removal
- Target maximum cleaning frequency of 1.5 p/b/g

7.0 Denier Mercury Removal Summary

Carbon ID	Injection Rate (lb/h)	Injection Concentration (lbs/MMacf)	Removal Efficiency (%)
FGD	20	0.6	87
FGD	25	0.8	91
FGD	30	1.0	94
FGD	35	1.1	93
FGD	45	1.3	91
FGD	55	1.6	92

- Injection concentration calculated at full load flow condition
- Injection periods varied from 3 days to 10 days
- 0.62 average p/b/h during test program

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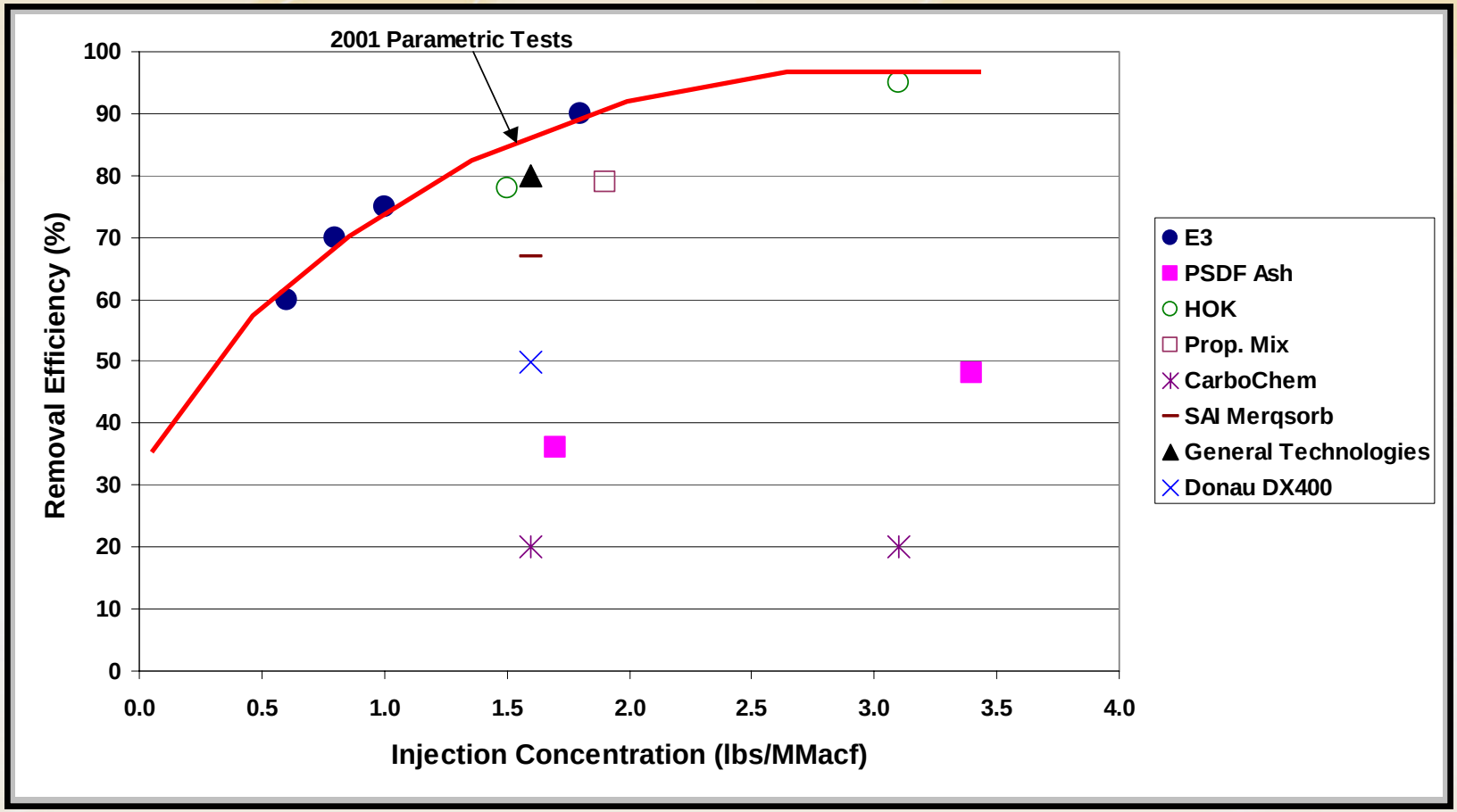
Alternative Carbon Tests

Broaden the options of suppliers and sorbents evaluated in this program

- Injected using 900 lb super sacs & Port-a-Pac Injection system
- Various carbon tested:
  - 9 different sorbent suppliers invited
  - 8 different sorbents tested
- Short-term test (8 hours – few days)
- Normal unit operations (i.e. not full load)

Alternative Carbon Test Results



Conclusions

MERCURY RESULTS

- Maximum carbon injection rate was limited by cleaning frequency on ALL tests
- Inlet mercury varied by a factor of five, from 4.2 to 21 lb/TBtu
- Outlet mercury emissions ranged from 0.6 – 2.5 lb/TBtu
- Average mercury removal during the test program was approximately 85%
- Outlet Emission rate is a better performance indicator than % removal

Conclusions

BAGHOUSE DESIGN

- Activated carbon injection systems are simple and reliable
- Lower the A/C the better, 6:1 ft/min seems ideal from performance & cost standpoints
- Higher denier fabrics (7.0 denier) improved pressure drop performance (less cleanings per bag)

Commercialization Conflict

Buyers and sellers have conflicting needs on first installations

- Buyer want guarantees and lowest price
- Seller needs flexibility and money to fix unanticipated problems

Commercialization Steps (TOXECON™)

1. Laboratory testing
2. Pilot-scale testing
   - Various pilot tests in 1990's (EPRI funding)
3. Full-scale, short term field tests
   - DOE Phase I tests, 2001
   - DOE year long test, 2003 – 2004
4. Full-scale field tests at multiple sites
5. Long-term demonstration
   - Clean Coal Program, start-up November 2005
6. Widespread implementation
   - About 6 RFP's already released

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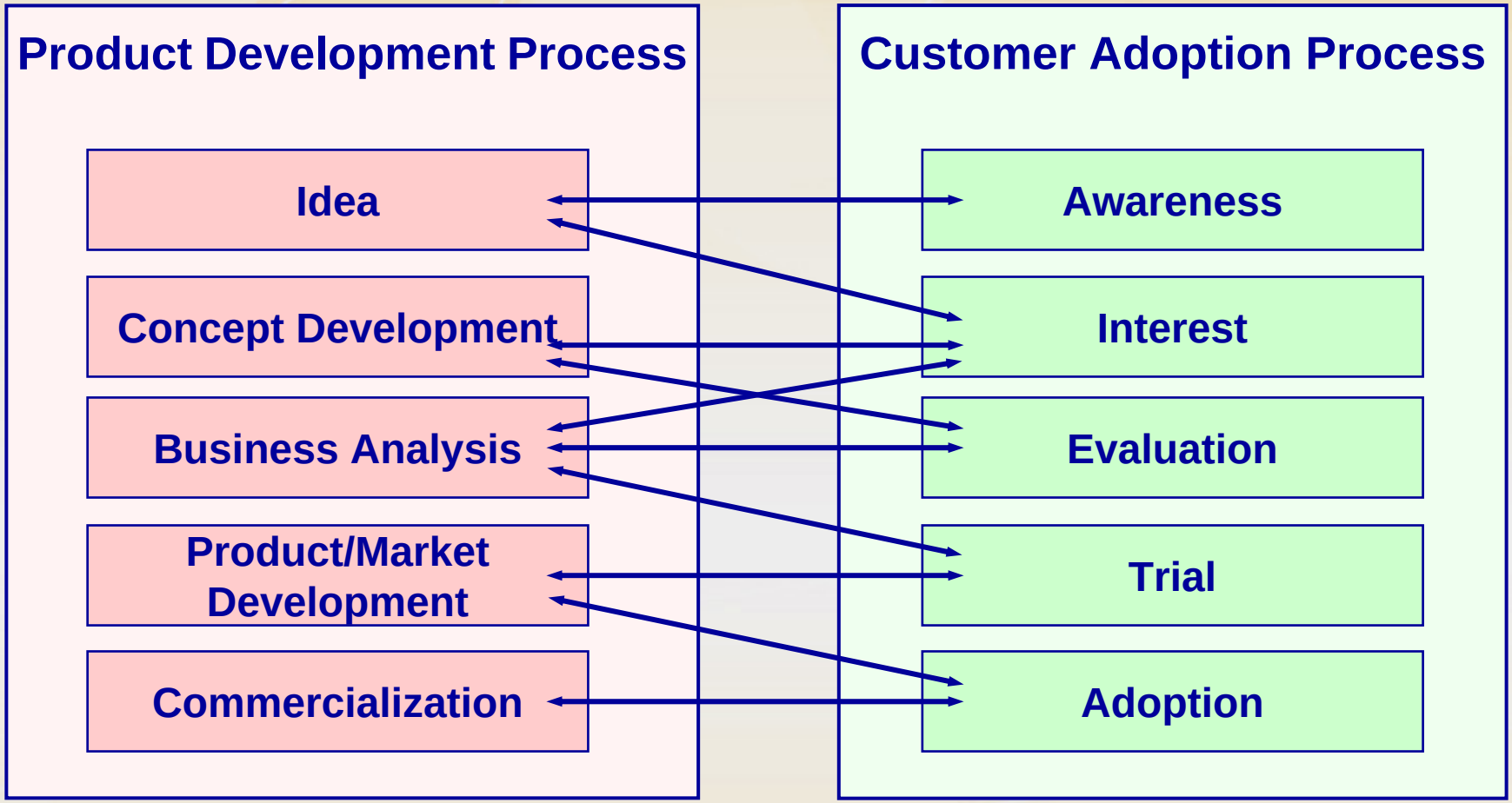
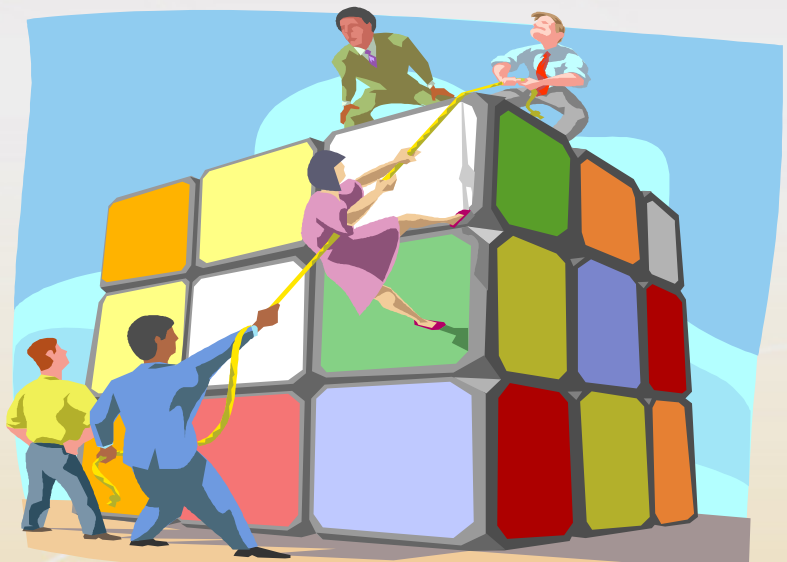
Technology Development and Customer Adoption Processes



Source: Kottler

Clean Coal Program

- Provides a non-interest bearing loan from DOE
- Encourages suppliers and power generators to team in technology development
- Reduces risk for both industry and utilities
- Must repay government for their portion
  - Payback based on sales of new products



TOXECON™ – 270 MW Demonstration

- **Presque Isle Power Plant, Marquette MI**
  - **Units 7-9**
  - **PRB Coal**
- **$53.3M**
  - **$24.9M DOE**
  - **$28.5M We Energies**
- **90% Hg Control**
  - ∗ **$SO_2 \Rightarrow 70\%$**
  - ∗ **$NO_X \Rightarrow 30\%$**
- **Start-up November 2005**

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